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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B23B 31/40, B65H 75/24 — A1

(11) International Publication Number: WO 94/06590

(43) International Publication Date: 31 March 1994 (31.03.94)

(21) International Application Number: PCT/SE93/00749

(22) International Filing Date: 16 September 1993 (16.09.93)

(30) Priority data:
9202681-4 17 September 1992 (17.09.92) SE

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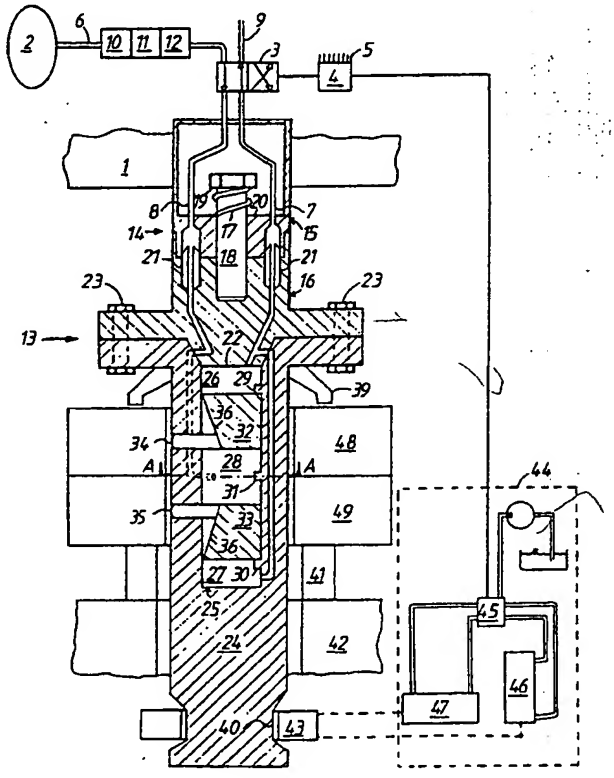
(81) Designated States: DE, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
In English translation (filed in Swedish).

(54) Title: PNEUMATICALLY OPERATED DEVICE FOR CENTERING AT LEAST ONE WORKPIECE IN A MACHINE TOOL

(57) Abstract

This invention relates to a mandrel (13) for centering and clamping at least one workpiece (48, 49) in a machine tool (1). The mandrel (13) incorporates movable pressure pistons (32, 33) which are actuated by compressed air to move in the axial direction. The pressure pistons (32, 33) are fitted with a group of centering pins (34, 35), which are actuated by respective inclined planes (36) arranged on the pistons (32, 33). When the respective pistons (32, 33) are displaced, the centering pins (34, 35) within the respective groups are displaced the same distance outwards due to the identical design of the inclined planes (36), which causes the respective workpieces (48, 49) to be centered in relation to the axial centreline of the mandrel (13). Both pistons (32, 33) are controlled by the same pressure source (2), and will therefore always centre both workpieces (48, 49) independently of each other, and with the same total centering force.



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PNEUMATICALLY OPERATED DEVICE FOR CENTERING AT LEAST ONE WORKPIECE IN A MACHINE TOOL.

This invention relates to a device for centering at least one workpiece in a machine tool according to the preamble to patent claim 1.

State of the art.

When workpieces are machined, e.g. during cutting of gears, it is often desirable to be able to clamp several workpieces simultaneously to the machine tool.
The combined centering and clamping mandrels which are designed for the internal centering and clamping several workpieces to machine tools and which are currently available generally only manage to clamp workpieces with dimensions within a rather narrow range.

When it is desired to machine workpieces with dimensions which differ only to a relatively small degree from the dimension of the first workpiece with a machine tool equipped with such a mandrel, the mandrel must be replaced. In order to be able to machine workpieces of several different dimensions in such cases, access to several different mandrels is therefore required. This involves relatively high investments in these mandrels, with handling which is both expensive and time-consuming.

In our Swedish patent application SE 88 02 603 - 4 a chuck is described which is suitable for relatively wide ranges of dimensions but which incorporates both hydraulic centering and clamping, which requires a relatively expensive, complicated structure with high sealing requirements, among other things. The above-mentioned chuck is designed for machining a single workpiece and rotating it during machining.
Unlike chucks used for turning, for example, centering and clamping mandrels need not rotate during machining,

thereby allowing simpler, cheaper structures.

Objective of the invention.

The objective of this invention is to provide a mandrel designed for internal centering of at least one workpiece in a machine tool so that the same mandrel can be used for centering and clamping workpieces with dimensions which vary within relatively wide limits without any reduction in centering accuracy. For this purpose the mandrel according to the invention is characterised by the features described in the characterising part of the main claim.

The centering device according to the invention affords advantages in the form of a cheap, reliable device with a long life which allows rapid setting variations when the machine tool is to be used for machining workpieces with other dimensions. The mandrel is available in several different versions and in different dimensions adapted to the dimensions of different workpieces.

It may be noted that a mandrel according to the invention has a working range of 13 millimeters, according to one embodiment, whilst a comparable conventional mandrel now available on the market, has a diametric working range of only a few tenths of a millimeter, depending on its design. If the working range for the respective solutions are compared it will be realised that a mandrel according to the invention can replace a large number of conventional mandrels, resulting in major savings in investments.

Another objective is to provide a relatively simple, cheap centering device which, according to an advantageous embodiment of the invention, is achieved in that the pressure medium used is compressed air which considerably reduces the sealing requirements of the

device. At the same time the device can be designed so that it can be replaced quickly and simply.

Additional features and advantages of the mandrel according to the invention are indicated in the attached description of an embodiment. The description refers to the attached figures.

List of figures.

Figure 1 shows diagrammatically a longitudinal section of a mandrel according to the invention, vertically mounted on a machine tool.

Figure 2 shows a radial cross-section A-A of the centering unit of the mandrel according to Figure 1.

Description of an embodiment.

Figure 1 shows a device for the internal centering and clamping of two workpieces for machining in a machine tool, preferably for cutting gears. The device comprises a machine tool 1 with a non-rotary clamping device 13 (called mandrel in the following), consisting of a basic unit 14, a centering unit 24 and a clamping unit 39. Machine 1 also incorporates a fixture 41 fitted to a fixture table 42 supported by machine tool 1, to which fixture 41 two workpieces 48, 49 are clamped for the purpose of machining, by a method of prior art, of cutting tools not shown here and driven by machine tool 1.

Figure 1 shows diagrammatically a pneumatic system for controlling mandrel 13 during the centering, clamping and detaching of the two workpieces 48,49. For the sake of clarity figure 1 only shows, in sectionally marked form, parts belonging to mandrel 13 according to the invention. The pneumatic system incorporates a compressed air unit 2 which is connected by a first pipe 6 to a valve 3 via a

pressure regulator 10, a moisture separating unit 11, and an oil mist unit 12 for adding lubricating oil to the compressed air. A second pipe 7 connects valve 3 to an upper and lower chamber 26, 27, respectively, which are called first chambers in the following, and which are arranged in centering unit 24. A third pipe 8 connects valve 3 to a second central chamber 28, which is also arranged in centering unit 24. The second and third pipes 7, 8, respectively, pass through the basic unit 14 to centering unit 24. Valve 3 has a fourth connection 9 to atmospheric pressure and is controlled by a control unit 4, which receives signals on a cable bundle 5 from a number of different sensors (not shown here) and controls the centering and clamping process according to a predetermined sequence.

Basic unit 14 of mandrel 13 is rotatably mounted and axially secured to machine tool 1 and consists of an upper section 15 and a lower section 16. A certain relative axial movement is possible between both these sections 15, 16. Lower section 16 is actuated towards its upper end position shown in Figure 1 by means of a spring element 17, which encloses the upper section of a control pin 18 mounted displaceably in section 15 and secured in section 16. Spring 17 forces section 16 in contact with section 15 due to support against both an upper shoulder 19 on pin 18 and an upper surface 20 on section 15. The second and third pipes 7, 8 respectively, which pass through basic unit 14, are equipped by a method of prior art with sealing elements 21 designed to prevent leakage in the plane of division between both sections 15, 16 when they are displaced from each other in the axial direction. Sealing elements 21 are advantageously designed as sleeves permanently arranged in either section 15, 16, and are displaceably mounted in the second section.

Centering unit 24 of mandrel 13 is detachably secured to

basic unit 14 by means of a number of fixing mechanisms 23 which, according to the invention, consists of a number of bolted joints.

Centering unit 24 comprises a cylinder 25 which is divided into the above-mentioned first and second chambers 26, 27, 28 by two pressure pistons 32, 33 which are movable in the axial direction. Upper piston 32 is designated as a first pressure piston and separates upper chamber 26 from the second central chamber 28, whilst lower piston 33 is designated as a second pressure piston and separates lower chamber 27 from the second central chamber 28. Both pressure pistons 32, 33 have the same basic design, but are reversed.

Furthermore, pressure pistons 32, 33 are provided with a number of inclined planes 36 designed to actuate a number of centering mechanisms 34, 35, to centre against workpieces 48 49. Planes 36 are evenly distributed along the circumference of the respective pistons 32, 33 (see Figure 2). According to the embodiment described in the example each piston 32, 33 is designed with three such planes 36. Each plane 36 is provided with a groove 37 in the axial longitudinal direction of the respective planes 36, with which groove a centering mechanism 34, 35 interacts to provide axial mobility but radial clamping relative to pistons 32, 33. Centering mechanisms 34,35 are preferably designed as cylindrical pins. In this embodiment centering unit 24 is therefore fitted with six centering pins 34, 35. Pins 34, which are arranged on first piston 32, may be said to constitute a first group and pins 35, which are arranged on second piston 33, may be said to constitute a second group of centering pins. Groove 37 can of course be replaced by some other form of dimensionally stable interaction where pins 34, 35 are allowed to move in a normal plane to the respective inclined plan 36, when pressure pistons 32, 33 are displaced in the axial longitudinal direction of mandrel 13. Centering pins 34, 35 are allowed to move in a radial direction relative to the central axis of mandrel

13, through a respective hole 38 designed for this purpose in the wall of centering unit 24.
In each chamber 26, 27, 28 there is a built-in stop member 29, 30, 31. Stop members 29, 30, 31 are designed as pins according to this embodiment.
For clamping and locking workpieces 48, 49 mandrel 13 is fitted with the above-mentioned clamping unit 39, here in the form of a clamping bell. Clamping bell 39 can be controlled to clamp or to be released from workpieces 48, 49, by lowering mandrel 13 against fixture table 42, by actuating a hydraulic cylinder arranged in machine tool 1 and not shown here. Clamping bell 39, which clamps both workpieces 48, 49 against fixture 41 in the axial direction, is detachably secured to centering unit 24.

The machine tool is trimmed by the following method of prior art:

Basic unit 14 of mandrel 13 is fitted and secured against axial movement to machine tool 1 by a method of prior art (not shown here). This is normally only done with the first installation. Centering unit 24 of mandrel 13 is then fitted and secured to basic unit 14 by means of bolted joints 23. Basic unit 14 is provided with a projecting conical control section 22 and centering unit 24 is provided with a conical recess interacting with it. The arrangement enables centering unit 24 to be controlled to a centred position, which is correct relative to the central axis of mandrel 13, and hence also relative to the tool not shown here and secured to machine tool 1.

Workpieces 48, 49 is then fitted to fixture 41. Upper workpiece 48 is designed to be centred by the first group of centering pins 34 and lower workpiece 49 is designed to be centred by the second group of centering pins 35. The procedure described above can of course be varied if so desired.

In the next stage of the procedure mandrel 13 is lowered towards and in through workpieces 48, 49 by means of a hydraulic cylinder arranged in machine tool 1 as far as the position shown in Figure 1. This position is defined by the fact that clamping bell 39 does not clamp against upper workpiece 48, but by the fact that both groups of centering pins 34, 35 are located in such a position that they clamp radially against the respective workpieces 48, 48.

The fact that the correct position has been reached is sensed by position sensors of prior art, not shown here, which interact via control unit 4 with the hydraulic system of machine tool 1, which brings about the displacement movement.

Mandrel 13 according to the invention then centres both workpieces 48, 49 as follows:

Mandrel 13 is pressurised via the first pipe 6 from compressed air unit 2 to valve 3, which in a primary position transmits the pressure to second power 7, whilst third pipe 8 is connected to atmospheric pressure via fourth connection 9 of the valve. The pressure is fed further through second pipe 7, which pass through basic unit 14 to centering unit 24, where the respective first chambers 26, 27 are therefore pressurised. Both pressure pistons 32, 33 are therefore actuated to move axially towards each other, at which centering pins 34, 35 are actuated by the inclined planes 36 to move radially outwards in the respective holes 38, and therefore to clamp with a centering action to workpieces 48, 49.

Third stop member 31, which is arranged in second central chamber 28, prevents both pistons 32, 33 from coming into contact with each other, which would cause the connection of third pipe 8 to second chamber 28 to be blocked. Centering pins 34, 35 in the respective groups are moved the same distance outwards because of the identical

design of inclined planes 36, which cause the respective workpieces 48, 49 to be centred relative to the axial centreline of mandrel 13. However, pins 34 of the first group need not necessarily be displaced the same distance as pins 35 of the second group. Both pistons 32, 33 are actuated by the same pressure and can therefore be provided with variable axial displacement. This in turn means that both workpieces 48 49 do not need to have the same inside diameter when pressure pistons 32, 33 are allowed to displace the respective groups of centering pins 34, 35 different distances. Both pistons 32, 33 are controlled by the same pressure source 2 and will therefore always centre both workpieces 48, 49 independently of each other, and with the same total centering force.

When a pressure sensor senses that a predetermined pressure, which represents completed centering, has been reached, control unit 4 receives a signal indicating this. This then transmits a signal to a solenoid valve unit 45, incorporated in a hydraulic system 44 of prior art, shown diagrammatically in Figure 1, which system actuates hydraulic cylinders 46, 47. These attend to a grab mechanism 43 arranged in the fixture table to grip a centre section 40, located at one end of centering unit 24, and that the entire centering unit 24 is displaced by means of grab mechanism 43, against the action of spring element 17, in an axially downward direction relative to upper section 15 of the basic unit so that clamping bell 39 clamps against upper workpiece 48. Workpieces 48, 49 can therefore be clamped against fixture 41 with the desired clamping force.

This axial clamping force is much greater than the radial centering force, which means that centering pins 34, 35 will slide somewhat relative to the inner face of the respective workpieces 48, 49.

The axial displacement of centering unit 24 also causes lower section 16 of basic unit 14 to be displaced, whilst upper section 15 remains on the same axial level as

before due to its permanent fastening to machine tool 1, which is not lowered. There is therefore a certain axial relative movement between both sections 15, 16 of basic unit 14. Sealing elements 21 prevents compressed air leakage in the plane of division between both these sections 15, 16.

During the machining phase the mandrel is driven by fixture table 42, which in turn is driven by a motor arranged in machine tool 1. The rotary force is transmitted from fixture table 42 to mandrel 13 via fixture 41 and workpieces 48, 49 clamped between fixture 41 and clamping bell 39, to clamping bell 39 non-rotationally arranged on the mandrel.
The mandrel can rotate either in steps or steplessly, depending on the type of machining.
According to a possible alternative embodiment the machining tool is movable around workpieces 48, 49, whilst mandrel 13 is therefore stationary and does not rotate.

After machining the release process takes place as follows:

Control unit 4 receives a signal, either manually or automatically, to indicate that the machining has been completed, whereupon it transmits a signal to hydraulic system 44, which releases and removes grab mechanism 43 from central section 40 of centering unit 24. This causes spring element 17 to actuate lower section 16 of basic unit 14 to be returned to the position shown in Figure 1, whereby clamping bell 39 releases upper workpiece 48.
Valve 3 is then controlled by control unit 4 to move to a secondary position, where the pressure is transmitted to third pipe 8, whilst second pipe 7 is connected to atmospheric pressure via fourth connection 9 of the valve. Second central chamber 28 is therefore

pressurised, whilst the pressure in the respective first chambers 26, 27 drops towards atmospheric pressure. Both pressure pistons 32, 33 are therefore actuated to be displaced axially from each other, whereupon centering pins 34, 35 are actuated to be displaced radially inwards because of the dimensionally stable interaction between grooves 37 made in planes 36 and the respective pins 34, 35, and therefore to release the respective workpieces 48, 49. First and second stop member 29, 30 respectively, arranged in the respective first chambers 26, 27, prevent both pressure pistons 32, 33 from returning such a distance that the outlet of second pipe 7 is blocked in the respective chambers 26, 27. Otherwise it would be impossible for these chambers 26, 27 to be pressurised when the next workpiece is centred. As mentioned above the three stop members 29, 30, 31 according to this embodiment consist of built-in pins, but this need not necessarily be the case. They may alternatively consist, for example, of axially directed pins arranged on the respective pressure pistons 32, 33 or built-in locking rings.
According to the process described above the grab device is released before centering pins 34, 35, which can of course take place in the reverse order.

When control unit 4 has received a signal indicating that both grab mechanism 43 and centering pins 34, 35 have been released from workpieces 48, 49, a signal is transmitted to hydraulic system 44 to actuate a hydraulic cylinder incorporated in it for the axial displacement of mandrel 13. In a final stage the entire mandrel 13 is therefore raised by means of the hydraulic cylinder so that workpieces 48, 49 can be removed and new workpieces can be fitted to fixture 41 for machining.

The most significant advantage of the mandrel according to the invention over known solutions is that the same mandrel 13, alternatively centering unit 24, can be used

for centering different workpieces with dimensions which vary within relatively wide limits. In conventional mandrels the centering pins are often controlled by mechanical springs characterised by the fact that the force/deformation ratio is only linear within a very limited displacement range which only constitutes a small proportion of the total range. On the other hand the mandrel according to the invention, which is controlled by compressed air, is actuated by the same force, regardless of the displacement, which allows complete centering throughout the diameter range through which pins 34, 35 can be displaced.

Both workpieces 48, 49, according to the embodiment described, are therefore actuated by the same pressure source 2, which causes them to be centred, independently of each other, with the same force, even if they have a variable inner diameter. According to the embodiment described it is therefore possible, for example, to centre a single workpiece by means of the second group of centering pins 35, without affecting the centering accuracy. This is possible when the centering pins are actuated by mechanical springs.

If it is required to machine a new workpiece whose dimensions differ so much from previous workpieces that the mandrel is unable to effect the centering, bolted joints 23 which clamp centering unit 24 to basic unit 14, can be released quickly, whereupon this first centering unit is replaced by another centering unit with a working range in which the new workpiece can be machined.

The entire centering device 13 does not therefore need to be replaced but basic unit 14 remains fixed to machine tool 1. The economic and handling advantages of the invention therefore appear to be quite evident.

Because the centering and clamping are effected by means of a pneumatic system, instead of a hydraulic system, draining and filling of the system are avoided during

such changes, whilst the sealing requirements are considerably reduced.

A further major advantage of the mandrel according to the invention over known solutions is that there is always a certain excess pressure in second central chamber 28. When third pipe 8 is connected to atmospheric pressure and the respective first chambers 26, 27 are pressurised, a leakage flow occurs between the wall of cylinder 25 and the respective pressure pistons 32, 33. The excess pressure which is then generated in the second central chamber 28 causes a further leakage flow between the gap between the walls of holes 38 and the respective centering pins 34, 35.
This makes it extremely difficult for dirt to penetrate centering unit 24 via the gap mentioned, which is otherwise common to conventional solutions. When the second central chamber 28 has been pressurised a greater leakage flow through the gap is obviously generated.
This gives rise to reduced wear on the vital parts of the mandrel, and hence longer life.

Moisture separator 11 and oil mist unit 12 also contribute to increased life by preventing water from penetrating and lubricant is fed with compressed air at all times, thereby considerably reducing the risk of wear and corrosion on both pressure pistons 32, 33 and the wall of cylinder 25.

According to an alternative embodiment the mandrel has horizontal orientation. It may therefore also be desirable for both axial ends of the mandrel to be rotatably mounted on the machine tool, for example if the mandrel rotates at high speed during machining. In order to enable the workpiece or pieces to be mounted on the mandrel, the centering unit is completely separable into two different parts, suitably in a plane through the second chamber.

The embodiment described above in the example relates to centering of two workpieces. This number can of course be varied since the same advantages are achieved as long as every workpiece is actuated by a single pressure piston, and all the pressure pistons are actuated by the same pneumatic pressure.

Claims.

1) Device for centering at least one workpiece (48, 49) in a machine tool (1), which device incorporates a clamping device (13) with centering mechanisms (34, 35) located essentially symmetrically about a central axis, which mechanisms are connected to a pressure source (2) in order to centre the workpiece (48, 49), depending on its pressure medium, which pressure source (2) has a pipe connection (6, 7, 8) to a first or second chamber (26, 27, 28) located on both sides of at least one piston (32, 33), which, depending on the pressure in the respective chambers (26, 27, 28), can be displaced in a cylinder (25) arranged in the clamping device (13), which piston (32, 33) is in motion transmitting connection to at least one centering mechanism (34, 35) for both radial inward and outward movement relative to the central axis of the clamping device (13), whereby the force required for the radial inward and outward movement of the centering mechanisms (34, 35) is generated by the pressure medium, c h a r a c t e r i s e d in that the pressure medium is compressed air, and in that the displaceable mounting of the piston (32, 33) in the cylinder (25) allows compressed air leakage between the first and second chamber (26, 27, 28) so that in operation both chambers (26, 27, 28) have a certain excess pressure relative to atmospheric pressure.

2) Device according to claim 1, c h a r a c t e r i s e d in that the compressed air system incorporates both a moisture separating unit (11) and an oil mist unit (12) for the addition of lubricant to the compressed air.

3) Device according to one of claims 1 or 2, c h a r - a c t e r i s e d in that the centering mechanisms (34, 35) are located in a first and second normal plane relative to the central axis, and are actuated by a first and second piston (32, 33 respectively), arranged symmetrically about the central axis, between which pistons (32, 33) is bounded a common second chamber (28) which is pressurised after completed centering.

4) Device according to one of claims 1-3, in which the mandrel (13) comprises a clamping unit (39) driven by a hydraulic system, c h a r a c t e r i s e d in that both the compressed air and hydraulic system are controlled by an electrical control unit (4) which controls the centering and clamping process in a predetermined sequence, depending on a number of input signals.

5) Device according to one of claims 1-4, in which the clamping device (13) is a mandrel with a basic unit (14) fixed to the machine tool (1), and a centering unit (24) detachably mounted on the basic unit (14), and incorporating the centering mechanisms (34, 35), which units (14, 24) are provided with interacting stop points relative to the central axis, c h a r a c t e r i s e d in that the units mentioned (14, 24) also have common connecting points for the connection of pressure transmitting ducts (7, 8) arranged in the respective units (14, 24).

6) Device according to one of claims 1-5, c h a r a c t e r i s e d in that the motion transmitting connection between the centering mechanisms (34, 35) and the piston (32, 33) consists of a dimensionally (shape) bound interaction of grooves in which the piston (32,33) is designed with a groove (37) directed obliquely towards the central axis, for each centering mechanism (34, 35).

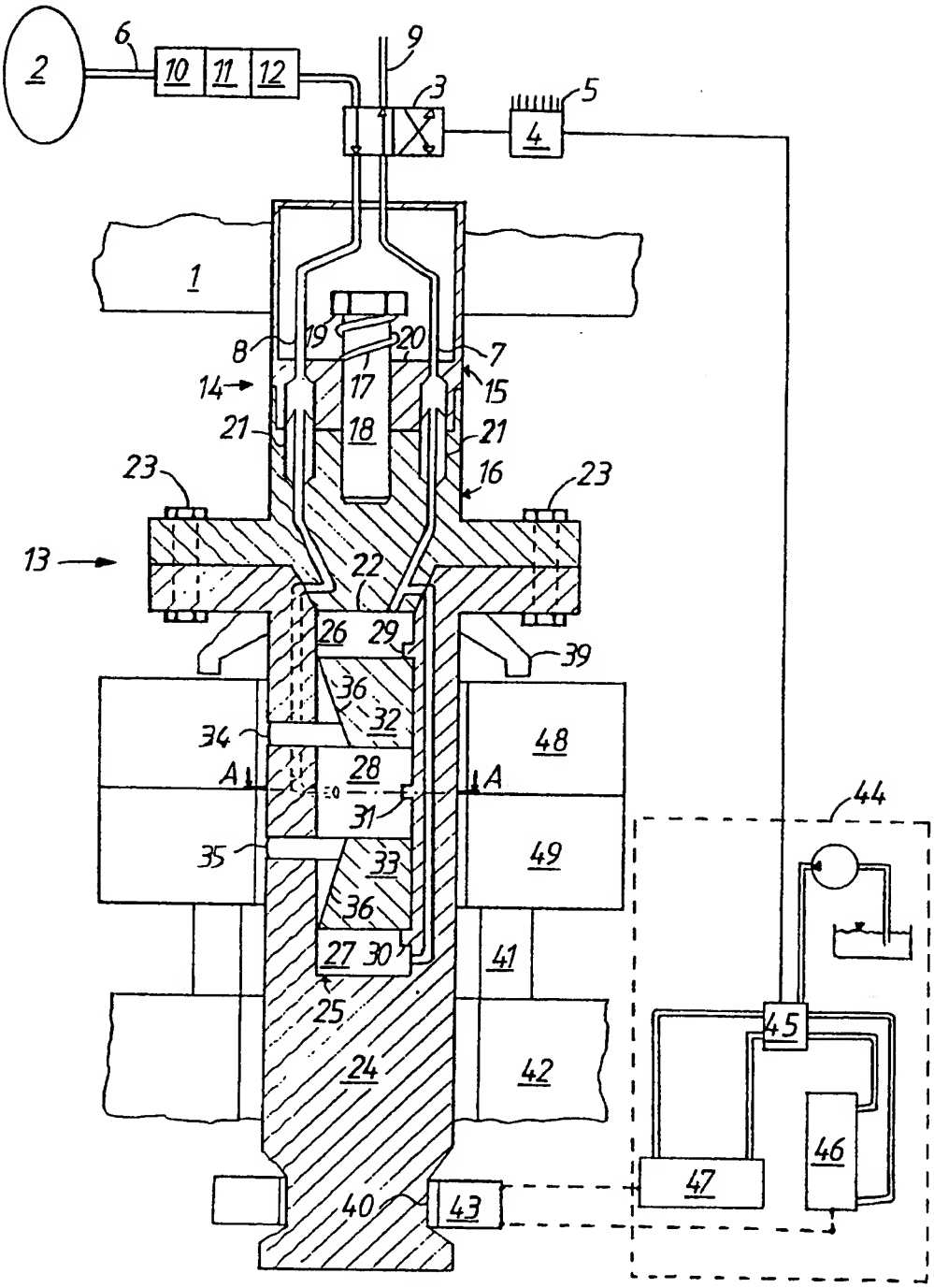
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Fig. 1

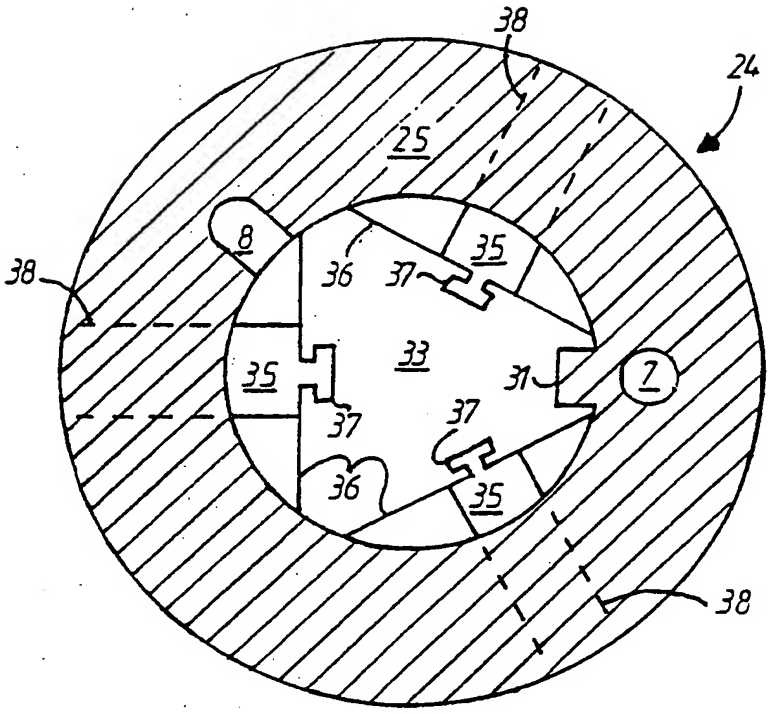

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 93/00749

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B23B 31/40, B65H 75/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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IPC5: B23B, B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE, A1, 2723964 (HOESCH WERKE AG), 7 December 1978 (07.12.78), figures 1,2, claim 1 --	1-7
A	DE, A1, 3319228 (SMW SCHNEIDER & WEISSHAUPT GMBH), 29 November 1984 (29.11.84), figures 1,2, abstract --	1-7
A	DE, A1, 3719102 (SMW SCHNEIDER & WEISSHAUPT GMBH), 15 December 1988 (15.12.88), figure 1, claims 1,2 --	1-7
A	EP, A1, 0413890 (SCHLUMPF AG), 27 February 1991 (27.02.91), figures 2-4, abstract --	1-7

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 December 1993	20 -12- 1993
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 93/00749

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR, A1, 2603838 (FORGES DE BOLOGNE), 18 March 1988 (18.03.88), figure 1, claim 1, abstract --	1-7
A	Derwent's abstract, No 84-223957/36, week 8436, ABSTRACT OF SU, A1, 1065104 (SEVAST EQUIPT INST), 7 January 1984 (07.01.84) --	1-7
A	US, A, 3079102 (DOUGLAS), 26 February 1963 (26.02.63), column 2, line 63 - column 3, line 11, figures 1,3 -- --------	1-7

INTERNATIONAL SEARCH REPORT
Information on patent family members

16/10/93

International application No.
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